

This Page Is Inserted by IFW Operations
and is not a part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

**As rescanning documents *will not* correct images,
please do not report the images to the
Image Problem Mailbox.**

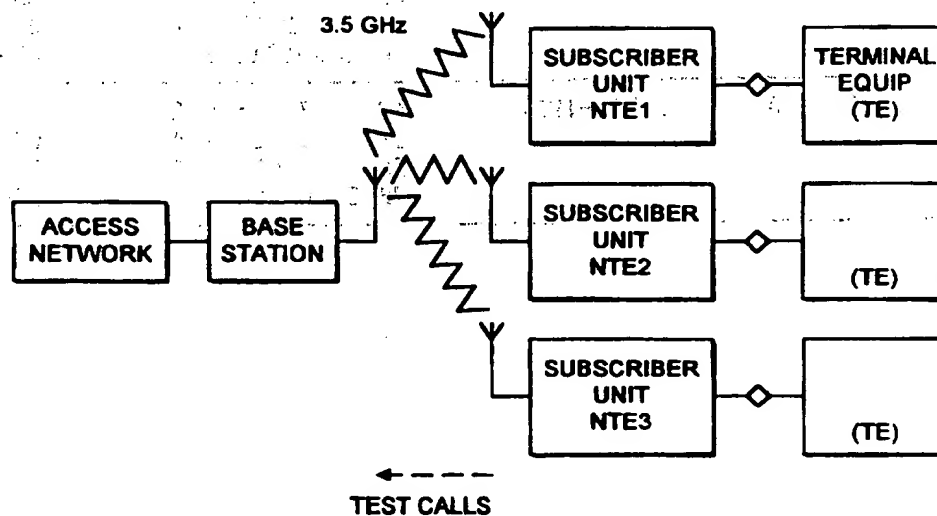
THIS PAGE BLANK (USPTO)

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : H04B 7/005		A2	(11) International Publication Number: WO 97/17769
			(43) International Publication Date: 15 May 1997 (15.05.97)
(21) International Application Number: PCT/GB96/02728		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).	
(22) International Filing Date: 7 November 1996 (07.11.96)		Published Without international search report and to be republished upon receipt of that report.	
(30) Priority Data: 9523063.7 10 November 1995 (10.11.95) GB 9602966.5 13 February 1996 (13.02.96) GB 9620519.0 2 October 1996 (02.10.96) GB			
(71) Applicant (for all designated States except US): IONICA INTERNATIONAL LIMITED [GB/GB]; Cowley Road, Cambridge CB4 4AS (GB).			
(72) Inventors; and			
(75) Inventors/Applicants (for US only): MARTIN, Paul, Maxwell [GB/GB]; 9 Taylors Field, Dullingham, Newmarket, Suffolk CB8 9XS (GB). GOODINGS, Rupert, Leslie, Alexander [GB/GB]; 33 Elizabeth Way, Cambridge CB4 1DD (GB). SHORE, Christopher, John [GB/GB]; 10 Evergreens, Chesterton, Cambridge CB4 1UP (GB).			
(74) Agent: SARUP, David, Alexander; Withers & Rogers, 4 Dyer's Buildings, Holborn, London, EC1N 2JT (GB).			

(54) Title: **METHOD AND APPARATUS FOR POWER CONTROL IN A TELEPHONE SYSTEM**

(57) Abstract

In apparatus and a method of transmitting messages in predetermined time slots within fixed length time frames, during a call a target power level of transmission is set by a second unit, the second unit is operative to measure the power level of a received message and to send a power level control signal to a first unit to adjust the power level of transmission during the call, the control signal being dependent upon the measured power level, and in which the power level of messages sent by the first unit at the start of a call is set dependent upon the power levels of messages sent by the first unit in previous successful calls to the second unit.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT:

AM	Armenia	GB	United Kingdom	MW	Malawi
AT	Austria	GE	Georgia	MX	Mexico
AU	Australia	GN	Guinea	NE	Niger
BB	Barbados	GR	Greece	NL	Netherlands
BE	Belgium	HU	Hungary	NO	Norway
BF	Burkina Faso	IE	Ireland	NZ	New Zealand
BG	Bulgaria	IT	Italy	PL	Poland
BJ	Benin	JP	Japan	PT	Portugal
BR	Brazil	KE	Kenya	RO	Romania
BY	Belarus	KG	Kyrgyzstan	RU	Russian Federation
CA	Canada	KP	Democratic People's Republic of Korea	SD	Sudan
CF	Central African Republic	KR	Republic of Korea	SE	Sweden
CG	Congo	KZ	Kazakhstan	SG	Singapore
CH	Switzerland	LI	Liechtenstein	SI	Slovenia
CI	Côte d'Ivoire	LK	Sri Lanka	SK	Slovakia
CM	Cameroon	LR	Liberia	SN	Senegal
CN	China	LT	Lithuania	SZ	Swaziland
CS	Czechoslovakia	LU	Luxembourg	TD	Chad
CZ	Czech Republic	LV	Latvia	TG	Togo
DE	Germany	MC	Monaco	TJ	Tajikistan
DK	Denmark	MD	Republic of Moldova	TT	Trinidad and Tobago
EE	Estonia	MG	Madagascar	UA	Ukraine
ES	Spain	ML	Mali	UG	Uganda
FI	Finland	MN	Mongolia	US	United States of America
FR	France	MR	Mauritania	UZ	Uzbekistan
GA	Gabon			VN	Viet Nam

METHOD AND APPARATUS FOR POWER CONTROL IN A TELEPHONE SYSTEM

The present invention relates to controlling power transmitted from a first transmitting and receiving unit to a second transmitting and receiving unit, in particular where units are at fixed locations.

Automatic power control is known and used widely in mobile GSM networks, in particular, being described in GSM specifications 05.05 and 05.08. In GSM networks, automatic power control is used to control the power transmitted from each mobile station and, optionally, can be used to control power transmitted from the base station. In GSM, automatic power control is used to reduce the level of power transmitted. An indicator of the initial transmit power to be used by the mobile station is sent in a message from the base station and the mobile station complies with this message.

The present invention provides a method of transmitting messages in predetermined time slots within fixed length time frames between a first transmitting and receiving unit and a second transmitting and receiving unit in which during a call a target power level of transmission is set by the second unit, the second unit is operative to measure the power level of a received message and to send a power level control signal to the first unit to adjust the power level of transmission during the call, the control signal being dependent upon the measured power level, and in which the power level of messages sent by the first unit at the start of a call is set dependent upon the adjusted power levels of messages sent by the first unit in previous successful calls to the second unit. The present invention also relates to corresponding apparatus.

Preferably a target power level is set by the second unit, the second unit being operative to measure the power level of a received message and to send a power level control signal to the first unit, the control signal being dependent upon the measured power level. Measurement and adjustment can continue automatically until the power received by the second unit meets the target power level, preferably within a predetermined tolerance measurement continues. Subsequently if there is variation in the received power at the second unit, the adjustment restarts.

Alternatively, the transmit power level can be set by the first unit itself dependent upon information of the power levels of previous successful calls. This is particularly useful for sending call set-up requests, system control messages and short messages to the second unit.

Preferably, a power level adjustment to decrease the transmit power level is only made provided interference is below a predetermined threshold.

The first unit is preferably a base station, and the second is preferably one of a plurality of subscriber units. Subscriber units are preferably at fixed locations. Transmissions are preferably by radio.

The received messages can be test calls. Where the first unit is a subscriber unit, test calls do not involve the user of the subscriber unit and can be made sufficiently frequently to keep the transmit power of a subscriber unit at an optimum level. Target power level can be set by the second unit using test calls.

Test calls can be made at any or all of the RF carrier frequencies available to a subscriber unit. Test calls can be made upon installation of the subscriber unit in the network.

Subscriber units can be categorised according to the propagation characteristics, such as path loss, which they experience. The frequency of test calls and/or size of ranges to be applied in determining whether power adjustments are required can be selected dependent on the categorisation given.

The present invention also relates to communication means comprising a base station and a plurality of subscriber units, the base station communicating with each subscriber unit by sending and receiving messages in predetermined time slots within fixed length time frames, in which during a call a target power level of transmission is set by the base station, the base station is operative to measure the power level of a received message and to send a power level control signal to the subscriber unit to adjust the power level of transmission during the call, the control signal being dependent upon the measured power level, and in which power level for messages sent by a subscriber unit at the start of a call is set dependent on the adjusted power levels of messages previously sent by that subscriber unit and received by the base station.

In a second aspect the present invention also provides method of transmitting messages in predetermined time slots within fixed length time frames between a first transmitting and receiving unit and a second transmitting and receiving unit in which the second unit is operative to measure the power level of a received message and to determine the level of interference due to other second units communicating with first units, said second unit

interference due to other second units communicating with first units, said second unit being operative to send a power level adjustment signal to the first unit dependent upon the measured power level, to increase or decrease the power level, a power decrease signal being sent and/or a power decrease being effected provided the interference level is determined as being below a predetermined threshold.

The present invention also relates to corresponding apparatus.

A first unit is preferably a subscriber unit. The second unit(s) are preferably base station(s).

The present invention in a second aspect also relates to communication means comprising a base station and a plurality of subscriber units, the base station communicating with each subscriber unit by sending and receiving messages in predetermined time slots within fixed length time frames, in which the base station is operative to measure the power level of a received message from a subscriber unit and to determine the level of interference due to subscriber units communicating with other base stations, the power levels for messages sent by said subscriber unit being reduced dependent on the power level of the received message provided the level of interference is below a predetermined threshold.

A preferred embodiment of the invention will now be described, by way of example, with reference to the drawings in which:

Figure 1 is a schematic diagram illustrating the system including a base station (BTE -

Base Terminating Equipment) and subscriber unit (NTE - Network Terminating Equipment);

Figure 2 is a diagram illustrating frame structure and timing for a duplex link;

Figure 3 is a further schematic diagram illustrating the system;

Figure 4 is a schematic graph illustrating power level tolerances applied over time;

Figure 5 is a graphical representation of one example of power level detection and adjustment;

Figure 6 is a schematic graph illustrating categorisation of subscriber units;

Figure 7 is a schematic topology of part of the preferred network showing four cells each having a base station and subscriber units.

Basic System

As shown in Figure 1, the preferred system is part of a telephone system in which the local wired loop from exchange to subscriber has been replaced by a full duplex radio link between a fixed base station and fixed subscriber unit. The preferred system includes the duplex radio link, and transmitters and receivers for implementing the necessary protocol.

There are similarities between the preferred system and digital cellular mobile telephone

systems such as GSM which are known in the art. This system uses a protocol based on a layered model, in particular the following layers: PHY (Physical), MAC (Medium Access Control), DLC (Data Link Control), NWK (Network).

One difference compared with GSM is that, in the preferred system, subscriber units are at fixed locations and there is no need for hand-off arrangements or other features relating to mobility. This means, for example, in the preferred system directional antennae and mains electricity can be used.

Each base station in the preferred system provides six duplex radio links at twelve frequencies chosen from the overall frequency allocation, so as to minimise interference between base stations nearby. The frame structure and timing for the duplex link is illustrated in Figure 2. Each duplex radio link comprises an up-link from a subscriber unit to a base station and, at a fixed frequency offset, a down-link from the base station to the subscriber unit. The down-links are TDM, and the up-links are TDMA. Modulation for all links is $\pi/4$ -DQPSK, and the basic frame structure for all links is ten slots per frame of 2560 bits i.e. 256 bits per slot. The bit rate is 512kbps. Down-links are continuously transmitted and incorporate a broadcast channel for essential system information. When there is no user information to be transmitted, the down-link transmissions continue to use the basic frame and slot structure and contain a suitable fill pattern.

For both up-link and down-link transmissions, there are two types of slot: normal slots which are used after call set-up, and pilot slots used during call set-up.

Each down-link normal slot comprises 24 bits of synchronisation information followed by 24 bits designated S-field which includes an 8 bit header, followed by 160 bits designated D-field. This is followed by 24 bits of Forward Error Correction and an 8 bit filler, followed by 12 bits of the broadcast channel. The broadcast channel consists of segments in each of the slots of a frame which together form the down-link common signalling channel which is transmitted by the base station, and contains control messages containing link information such as slot lists, multi-frame and super-frame information, connectionless messages and other information basic to the operation of the system.

During call set-up, each down-link pilot slot contains frequency correction data and a training sequence for receiver initialisation, with only a short S-field and no D-field information.

Up-link slots basically contain two different types of data packet. The first type of packet, called a pilot packet, is used before a connection is set up, for example, for an ALOHA call request and to allow adaptive time alignment. The other type of data packet, called a normal packet, is used when a call has been established and is a larger data packet, due to the use of adaptive time alignment.

Each up-link normal packet contains a data packet of 244 bits which is preceded and followed by a ramp of 4 bits duration. The ramps and the remaining bits left of the 256 bit slot provide a guard gap against interference from neighbouring slots due to timing errors. Each subscriber unit adjusts the timing of its slot transmissions to compensate for the time it takes signals to reach the base station. Each up-link normal data packet

comprises 24 bits of synchronisation data followed by an S-field and D-field of the same number of bits as in each down-link normal slot.

Each up-link pilot slot contains a pilot data packet which is 192 bits long preceded and followed by 4 bits ramps defining an extended guard gap of 60 bits. This larger guard gap is necessary because there is no timing information available and without it propagation delays would cause neighbouring slots to interfere. The pilot packet comprises 64 bits of sync followed by 104 bits of S-field which starts with an 8 bit header and finishes with a 16 bit Cyclic Redundancy Check, 2 reserved bits, 14 FEC bits, and 8 tail bits. There is no D-field.

The S-field in the above mentioned data packets can be used for two types of signalling.

The first type is MAC signalling (MS) and is used for signalling between the MAC layer of the base station and the MAC layer of a subscriber unit whereby timing is important.

The second type is called associated signalling, which can be slow or fast and is used for signalling between the base station and subscriber units in the DLC or NWK layers.

The D-field is the largest data field, and in the case of normal telephony contains digitised speech, but can also contain non-speech data samples.

Provision is made in the preferred system for subscriber unit authentication using a challenge response protocol. General encryption is provided by combining the speech or data with a non-predictable sequence of cipher bits produced by a key stream generator which is synchronised to the transmitted super-frame number.

In addition, the transmitted signal is scrambled to remove dc components.

Automatic Power Control

A typical topology of base stations/subscriber units is shown in Figure 3. Automatic Power

Control operates in the following manner for all MAC channels. At the start-up of a call

connection made at the MAC layer, the subscriber unit begins transmitting at a

predetermined power (see below). The received power at a base station is measured and

adjustment commands sent to the subscriber unit. The subscriber unit responds to these

commands by changing its transmit power by the increment suggested by the base station.

The base station measures the received power for the duration of the call and sends

appropriate commands to the subscriber unit.

At start-up of a connection at the MAC level, the base station measures the received signal

strength of transmissions from a particular subscriber unit for a short period (0.25s). This

gives a measurement the accuracy of which depends on the propagation conditions but is

typically not expected to be greater than the largest range (threshold j) as shown in figure

4. If the received signal strength lies outside this range ($\pm j$) then the base station

commands the subscriber unit to alter its transmit power.

Subsequently, a longer measurement period is used to provide a more accurate

measurement of the mean received signal strength. Again, if the received signal strength

lies outside the $\pm k$ range then the base station commands a change in transmit power

from the subscriber unit. The third measurement period is the one used in all subsequent

measurements and allows the most accurate measurement of mean received power. If the transmit power moves outside the $(\pm n)$ range then the base station will command the subscriber unit to alter its transmit power.

A typical process including each of the three above thresholds is illustrated in figure 5.

This shows the case where the first 0.25s measurement of base station received signal strength is outside the $(\pm j)$ range and as a consequence a first power change command is sent which adjusts the subscriber unit transmit power such that the signal strength received at the base station is within the $(\pm k)$ range but not the $(\pm n)$ range. A further power change command results after the third measurement period should the mean received signal strength lie outside the $(\pm n)$ range.

Determination of Initial Power level for transmissions at a Subscriber Unit

In the preferred network, calculation of initial transmit power is performed in the subscriber unit using information from several eg. four or five previous calls. This is possible because, in the preferred network, the subscriber units are fixed. Automatic power control in the preferred embodiment of the present invention optimises power levels by increasing as well as reducing transmit power from a subscriber unit.

There are special procedures operating in the subscriber unit for determining the correct power to be used at initialisation of either a call set-up request or a system control message. This is the power which is set by the subscriber unit before any control messages from the base station have been transmitted, for example, to adjust the power level. The

initial transmit power is determined at the subscriber unit based on the history of a number of calls on a particular RF carrier frequency. For each RF carrier frequency, initial transmit power is stored such that it is possible to set a different transmit power from the subscriber unit for each RF carrier frequency that could be used.

During the period for which a MAC connection is active, periodic power measurements are made by the subscriber unit so as to determine its own power setting. These are performed at the same rate as transmit power update signals are received from the base station. Each power measurement is used to update a running mean value of the transmit power. On deestablishment of a MAC connection, the current value of the running mean is used to update the initial transmit power value stored by the subscriber unit. The update is weighted by the number of previous MAC connections that are considered. For example, if a 5 call history is used then each update contributes 1/5 of its value to the initial transmit power setting. Each RF carrier signal has an associated initial transmit power value stored in respect of it. Each update will therefore only affect signals at the RF frequency on which the MAC connection was established.

Control of ranges applied in Automatic Power Control dependent on expected propagation characteristics

RF propagation characteristics between subscriber units and the base station can vary widely. In general, the standard deviation of variation in received signal strength increases with path loss (which is turn is loosely related to distance from the base station). Therefore, subscriber unit installations with high path loss exhibit greater variations in

signal strength than those with lower path losses. This is illustrated in figure 6, where subscriber unit NTE 1 has a lower path loss variation than subscriber unit NTE 2 which has the worst. (In Figure 6, S.D. denotes the standard deviation of path loss measurements). In the preferred power level control process which is used the population of subscriber units are divided into 12 possible path loss types, based on (i) fading frequency, (ii) fade depth and (iii) signal stability. Three of these types are denoted A, B and C in Figure 6. This classification is used to control two characteristics, namely (a) the convergence thresholds to be applied in determining whether a received signal has acceptable strength and (b) how often test calls are required (see below).

The convergence thresholds are the $\pm j$, k and n ranges described previously. These ranges are chosen dependent on path loss type such that the subscriber units operating with the highest channel stability and least fade depth are given tighter tolerances than subscriber units with lesser stabilities and greater fade depths.

Automatic Power Control using Test Calls

The initial transmit power from a subscriber unit is controlled using call history i.e. information of the power level acceptable for previous successful calls, as has already been discussed. It is important that customer calls are not relied upon for this process as they might well be too infrequent or old to be accurate. This could be for a number of reasons, for example, where customer is a low user or the customer is away on vacation for a long time. If no calls are made to the subscriber unit for long periods then it is possible for the initial transmit power setting to become outside the limits of what is currently acceptable.

This could cause unsatisfactory levels of interference to other subscriber units and, in the worst case, could prevent subscriber units from communicating with the base station.

Test calls are made from the base station to each subscriber unit communicating with the base station. A test call involves radio transmission using a TDMA scheme between base station and subscriber unit but does not involve communications to a telephone exchange nor does it result in any substantial processing activity at the subscriber unit. For example, the subscriber unit can still be used to make a PSTN call while a test call is in progress.

The length of the test call is selected to allow for a statistically accurate measurement of the mean received signal strength to be made. This in turn ensures that the adjustments made to the subscriber unit transmit power will be optimum for the prevailing propagation conditions.

In communicating with subscriber units, the base station periodically sends information specific to each subscriber unit of which RF carrier frequencies are:

- (i) preferred (the so-called 'white' channels)
- (ii) to be used if a preferred rf frequency is not available (the so-called 'grey' channels)
- (iii) not to be used (the so-called 'black' channels).

Each subscriber unit stores this information.

RF frequencies are categorised as 'black' if, for example, their use by a subscriber unit in

one sector of the network cell around a base station is likely to cause interference with transmissions from subscriber units in neighbouring sectors. RF frequencies are categorised as 'grey' where they provide poor quality but acceptable propagation.

Each subscriber unit maintains a Classified Carrier-List corresponding to the information received from the base station indicating radio frequencies that are preferred ("white"), frequencies that are only to be used due to the poor quality they provide if no preferred slot is available ("grey"), and frequencies which are not to be used ("black").

Test calls as described above are made upon installation of a subscriber unit, and at regular intervals to each subscriber unit, on each RF carrier marked as white or grey in the classified carrier list. This ensures that the initial transmit power of the subscriber unit is up to date thereby reducing the risk of no RF carrier frequency being available for a call due to RF propagation conditions.

This repetition rate of test calls to individual subscriber units is determined by considering the type classification applied to a particular subscriber unit, as described above. For example, subscriber units suffering poor propagation conditions are subject to more frequent test calls.

The test call scheduling is designed such that 12 separate test call schedules are specified with each subscriber unit communicating with a base station being assigned one of the 12 schedules.

At least one test call on each RF carrier frequency at each subscriber unit is attempted within the repeat period. For example, a subscriber unit classified as a type with good propagation characteristics may be assigned to a schedule of a test call every 47 hours whereas one classified as a type having poor propagation characteristics may have a test call schedule involving test calls every 4 hours.

Interference during Active Power Control

There are two types of interference; co-channel interference and adjacent channel interference as described below. A typical cellular topography is illustrated in Figure 7. The reference cell is that containing base station BTE 1. The available frequencies are divided into a number of subsets, denoted fs_1 , fs_2 , fs_3 .

Co-Channel Interference: Cells containing base station BTE 1 and base station BTE 4 operate with the same frequency set. Transmissions from subscriber unit NTE 1 to base station BTE 1 result in co-channel interference to base station BTE 4. The exact level of interference depends on the path loss between the two cells. Nevertheless, minimising the transmit power from subscriber unit NTE 1 minimises the level of uplink interference present at base station BTE 4.

Adjacent Channel Interference: Cells containing base stations BTE 1, BTE 2 and BTE 3 have mutually independent frequency sets, denoted fs_1 , fs_2 and fs_3 respectively. Each frequency set consists of a number of selected frequencies denoted f_n where n increases with increasing frequency. However, optimum usage of the available frequency sets will

involve base stations BTE 1, BTE 2 and BTE 3 having adjacent frequencies present in the frequency sets (i.e. if selected rf frequency denoted n is used at base station BTE 1 then selected rf frequency denoted $n+1$ would be used by base station BTE 2 or BTE 3). Interference is possible if the power transmitted by subscriber unit NTE 1 in adjacent channels ($n+1$ using the notation above) is not sufficiently attenuated and the path loss between subscriber unit NTE 1 and either base station BTE 2 or base station BTE 3 is low. Again this effect can be mitigated by ensuring that subscriber unit NTE 1 is transmitting at no more than near minimum power for successful reception.

Automatic power control involves measuring the received power level of a transmitting subscriber unit at the receiving base station over a predetermined time interval to determine the power adjustment required. Should interference occur then the measured power would be increased leading to control signals being sent to reduce the transmit power level of the subscriber unit. This overcompensation is avoided by measuring the level of interference, and only making downward adjustments to transmit power provided the interference level is below a predetermined threshold. When the interference level is too high, the base station is inhibited from sending a power decrease signal.

The level of interference is measured by determining received signal quality relative to received signal strength. Quality is determined by monitoring errors in received data, in particular by comparing expected and received Forward Error Correction (FEC) data or Cyclic Redundancy Check (CRC) data; or by evaluation of RMS vector error. Vector Error is a vector estimate of difference between an expected and received symbol amplitude and phase. Vector errors for all symbols in a slot are stored and integrated to

provide the Root Mean Squared (RMS) Vector Error. RMS Vector Error is a scalar quantity.

The RMS Vector Error is a scalar quantity which is calculated by taking the square root of the mean of the squared magnitudes of the vector errors. The vector errors are the differences between the estimated and true positions of the objects. The RMS Vector Error is a measure of the accuracy of the system. It is a scalar quantity which is calculated by taking the square root of the mean of the squared magnitudes of the vector errors. The vector errors are the differences between the estimated and true positions of the objects. The RMS Vector Error is a measure of the accuracy of the system.

The RMS Vector Error is a scalar quantity which is calculated by taking the square root of the mean of the squared magnitudes of the vector errors. The vector errors are the differences between the estimated and true positions of the objects. The RMS Vector Error is a measure of the accuracy of the system. It is a scalar quantity which is calculated by taking the square root of the mean of the squared magnitudes of the vector errors. The vector errors are the differences between the estimated and true positions of the objects. The RMS Vector Error is a measure of the accuracy of the system.

The RMS Vector Error is a scalar quantity which is calculated by taking the square root of the mean of the squared magnitudes of the vector errors. The vector errors are the differences between the estimated and true positions of the objects. The RMS Vector Error is a measure of the accuracy of the system. It is a scalar quantity which is calculated by taking the square root of the mean of the squared magnitudes of the vector errors. The vector errors are the differences between the estimated and true positions of the objects. The RMS Vector Error is a measure of the accuracy of the system.

CLAIMS

1. A method of transmitting messages in predetermined time slots within fixed length time frames between a first transmitting and receiving unit and a second transmitting and receiving unit in which during a call a target power level of transmission is set by the second unit, the second unit is operative to measure the power level of a received message and to send a power level control signal to the first unit to adjust the power level of transmission during the call, the control signal being dependent upon the measured power level, and in which the power level of messages sent by the first unit at the start of a call is set dependent upon the adjusted power levels of messages sent by the first unit in previous successful calls to the second unit.

2. A method of transmitting messages according to claim 1, in which the adjusted power levels of the previous N calls are averaged to provide the power level of messages sent by the first unit at the start of a call, N being an integer.

3. A method of transmitting messages according to claim 2, in which N is four.

4. A method of transmitting messages according to any preceding claim, in which steps of measurement of received power level and adjustment of power level of transmission are repeated until the power received by the second unit meets the target power level within a predetermined tolerance.

5. A method of transmitting messages according to claim 4 in which measurement continues automatically thereafter.

6. A method of transmitting messages according to claim 5, in which if there is variation in the measured received power beyond the predetermined tolerance, adjustment restarts.

7. A method of transmitting messages according to any of claims 1 to 6, in which some of the received messages are test calls.

8. A method of transmitting messages according to claim 7, in which where the first unit is a subscriber unit, test calls do not involve the user of the subscriber unit.

9. A method of transmitting messages according to claim 7 or claim 8, in which test calls are made sufficiently frequently to keep the transmit power of a subscriber unit at an optimum level.

10. A method of transmitting messages according to any of claims 7 to 9, in which the test calls are made at any or all of the RF carrier frequencies available to a subscriber unit.

11. A method of transmitting messages according to any of claims 7 to 10, in which test calls are made upon installation of the subscriber unit in the network.

12. A method of transmitting messages according to any of claims 7 to 11, in which second units are categorised according to propagation characteristics which they experience, and the frequency of test calls applied in determining whether power adjustments are required is selected dependent on the categorisation given.

13. A method of transmitting messages according to claim 1, in which at the start of a call the power level of transmission is set by the first unit dependent upon information of the power levels of the previous successful calls.

14. A method of transmitting messages according to any preceding claim, in which a power level adjustment to decrease the power level of transmission is only made provided interference is below a predetermined threshold.

15. A method of transmitting messages according to any preceding claim, in which transmissions are by radio.

16. Apparatus comprising a first transmitting and receiving unit and a second transmitting and receiving unit operative to transmit messages therebetween in predetermined time slots within fixed length time frames in which during a call a target power level of transmission is set by the second unit, the second unit is operative to measure the power level of a received message and to send a power level control signal to the first unit to adjust the power level of transmission during the call, the control signal being dependent upon the measured power level, and in which setting means are provided to set the power level of messages sent by the first unit at the start of a call dependent upon the adjusted power levels of messages sent by the first unit in previous successful calls to the second unit.

17. Apparatus according to claim 16, in which the first unit is a base station, and the second is one of a plurality of subscriber units.

18. Apparatus according to claim 16 or claim 17, in which subscriber units are at fixed locations.

19. Communication means comprising a base station and a plurality of subscriber units, the base station communicating with each subscriber unit by sending and receiving messages in predetermined time slots within fixed length time frames, in which during a call a target power level of transmission is set by the base station, the base station is operative to measure the power level of a received message and to send a power level control signal to the subscriber unit to adjust the power level of transmission during the call, the control signal being dependent upon the measured power level, and in which power level for messages sent by a subscriber unit at the start of a call is set dependent on the adjusted power levels of messages previously sent by that subscriber unit and received by the base station.

20. A method of transmitting messages in predetermined time slots within fixed length time frames between a first transmitting and receiving unit and a second transmitting and receiving unit in which the second unit is operative to measure the power level of a received message and to determine the level of interference due to other second units communicating with first units, said second unit being operative to send a power level adjustment signal to the first unit dependent upon the measured power level, to increase or decrease the power level, a power decrease signal being sent and/or a power decrease being effected provided the interference level is determined as being below a predetermined threshold.

21. Apparatus comprising a first transmitting and receiving unit and a second transmitting and receiving unit operative to transmit messages therebetween in predetermined time slots within fixed length time frames, in which the second unit is operative to measure the power level of a received message and to determine the level of interference due to other second units communicating with first units, said second unit being operative to send a power level adjustment signal to the first unit dependent upon the measured power level, to increase or decrease the power level, a power decrease signal being sent and/or a power decrease being effected provided the interference level is determined as being below a predetermined threshold.

22. Apparatus according to claim 21, in which the first unit is a subscriber unit, and the second unit is a base station.

23. Communication means comprising a base station and a plurality of subscriber units, the base station communicating with each subscriber unit by sending and receiving messages in predetermined time slots within fixed length time frames, in which the base station is operative to measure the power level of a received message from a subscriber unit and to determine the level of interference due to other base stations communicating with subscriber units, the power levels for messages sent by said subscriber unit being reduced dependent on the power level of the received message provided the level of interference is below a predetermined threshold.

1/4

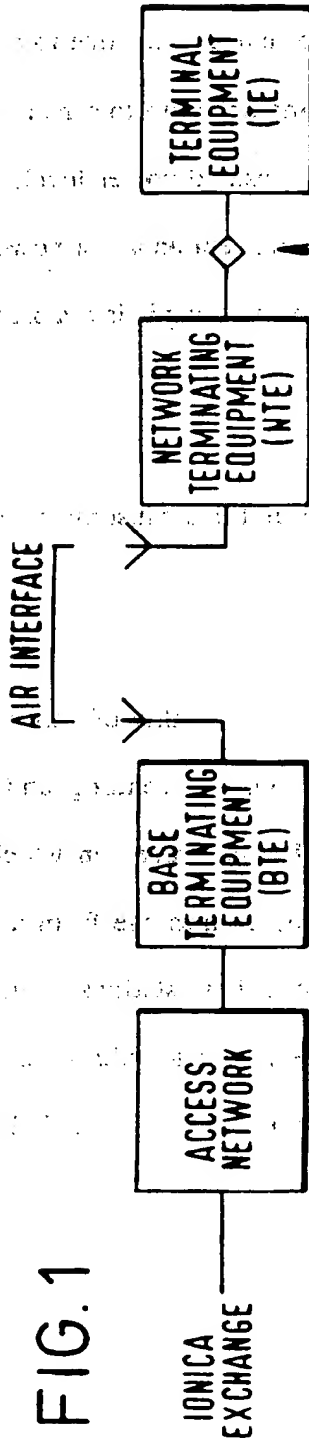
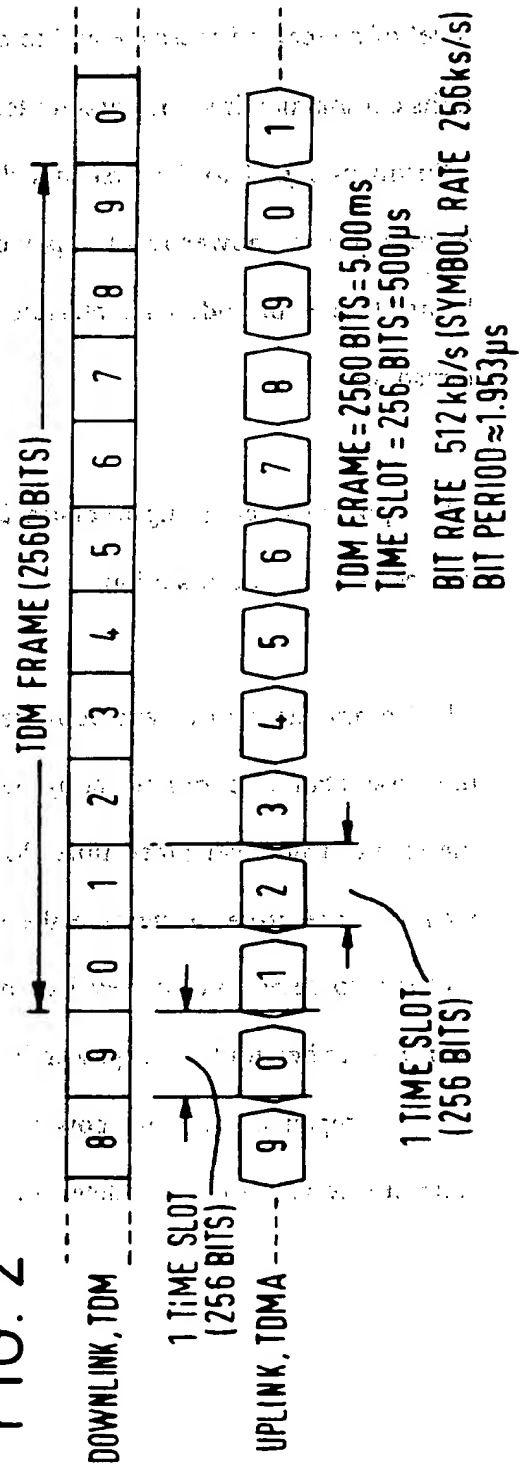


FIG. 1

SCOPE OF AIR INTERFACE PROTOCOL (AIP)

FIG. 2



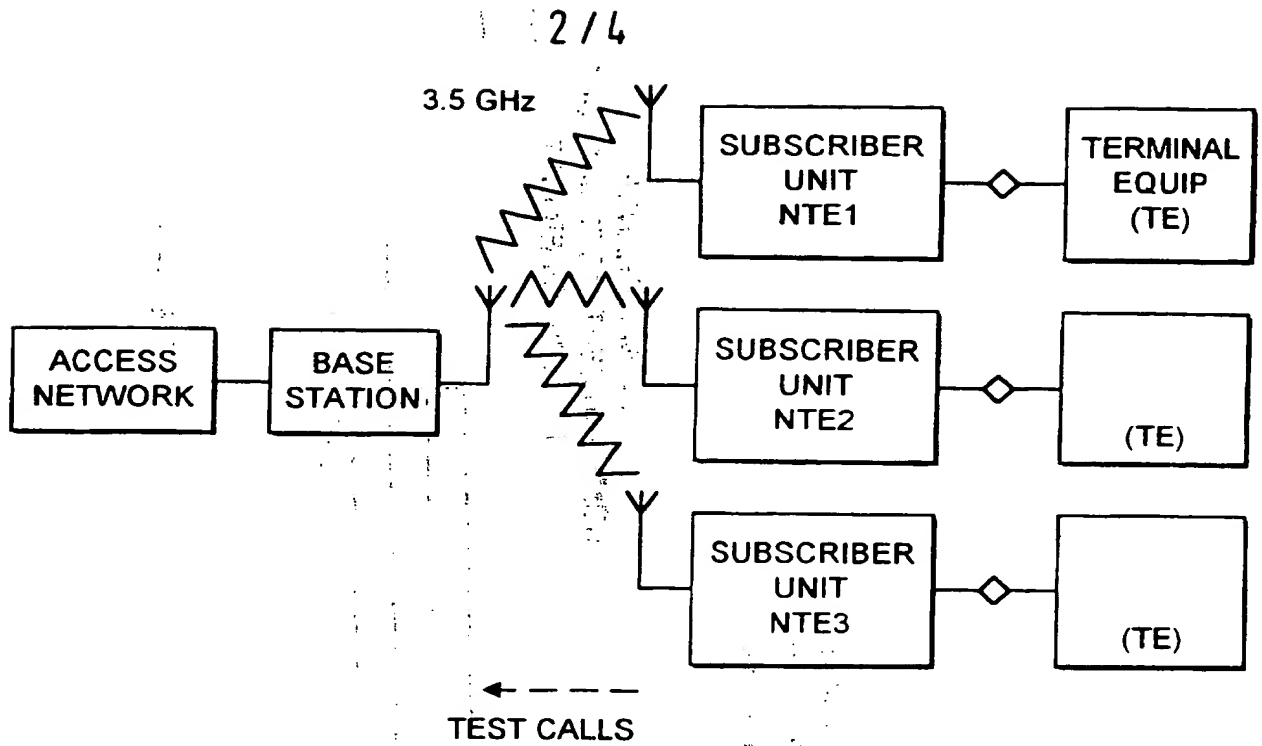


FIG. 3

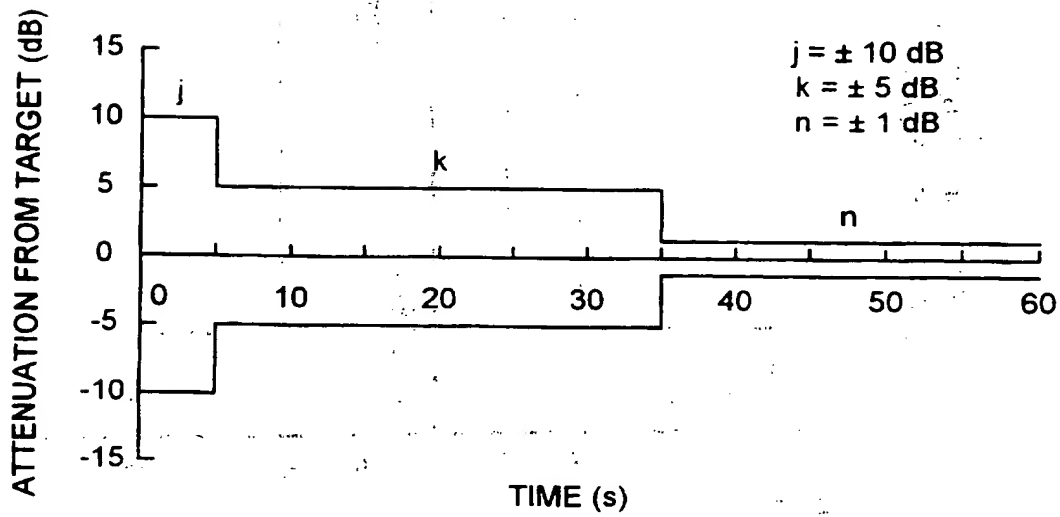


FIG. 4

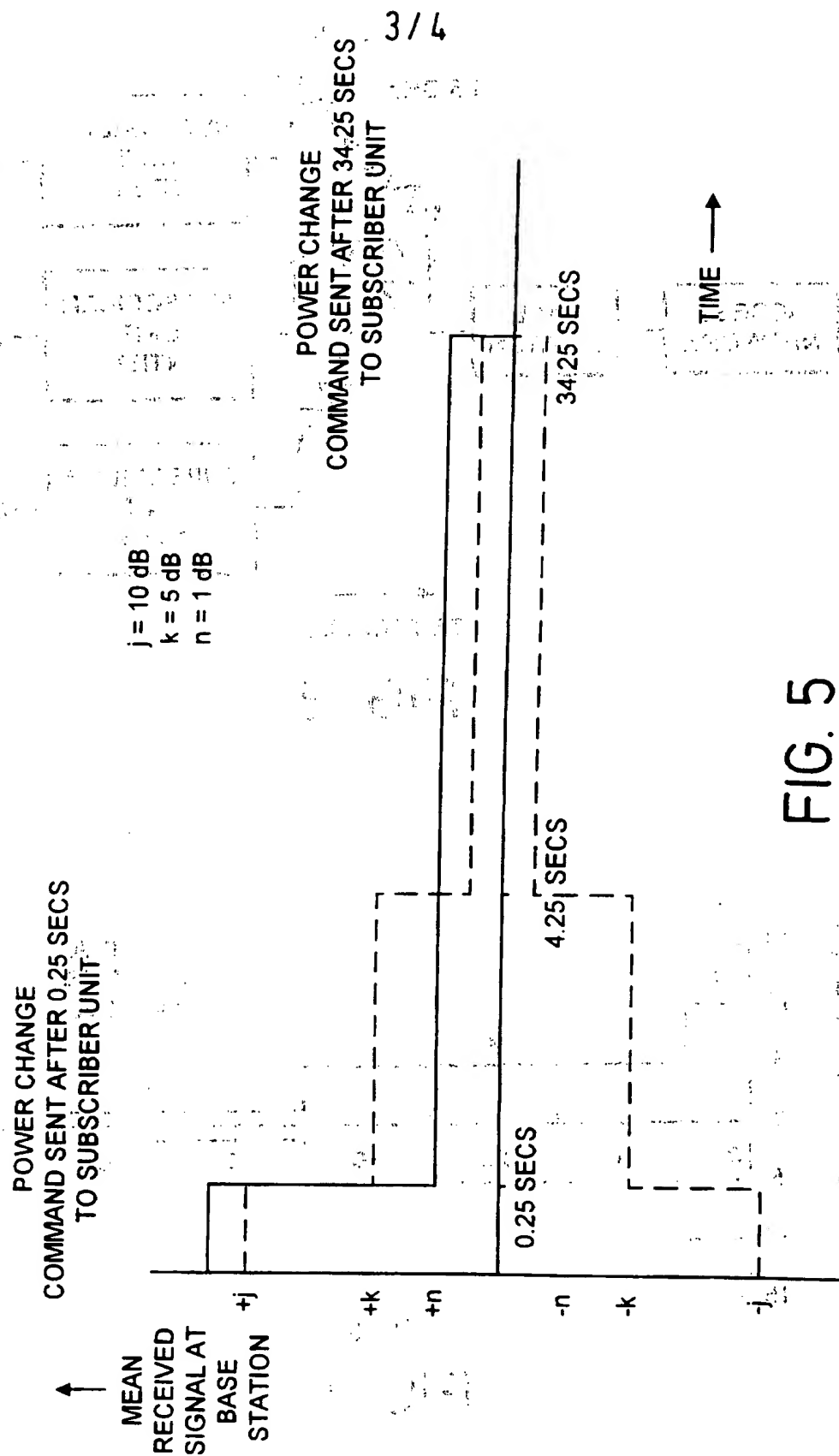
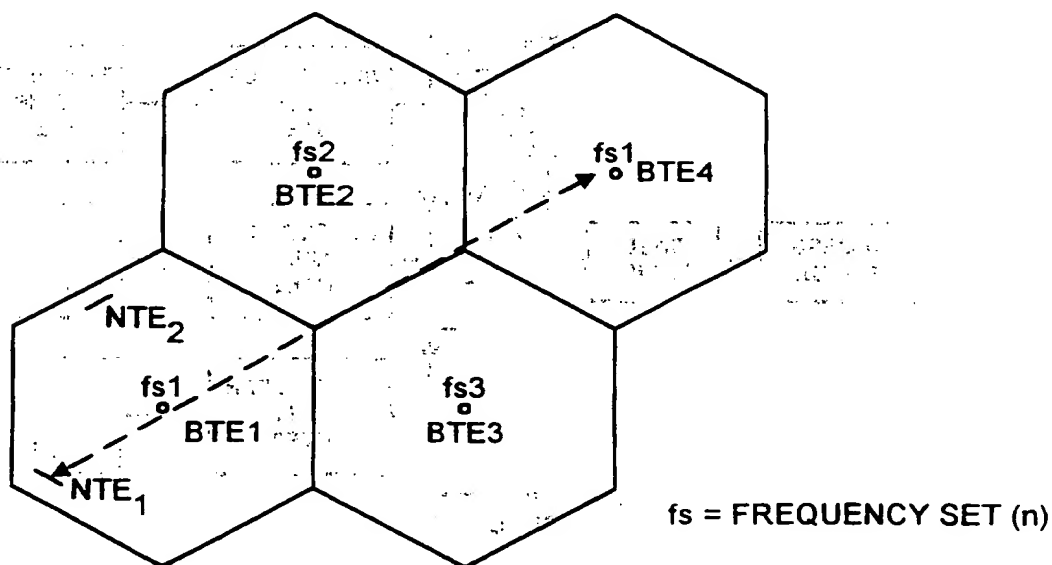
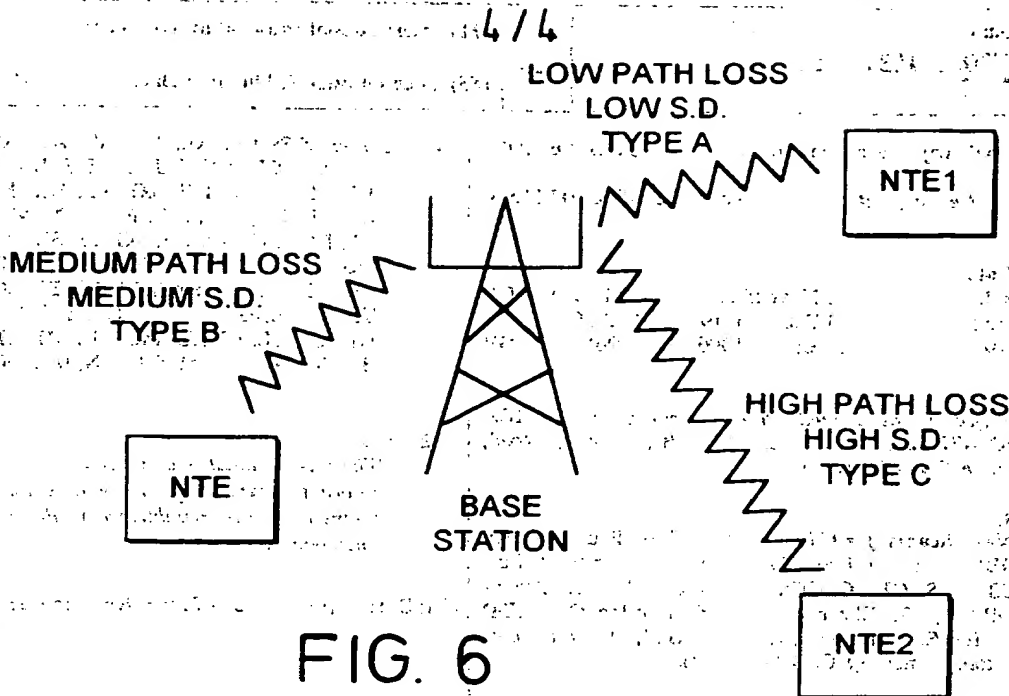


FIG. 5

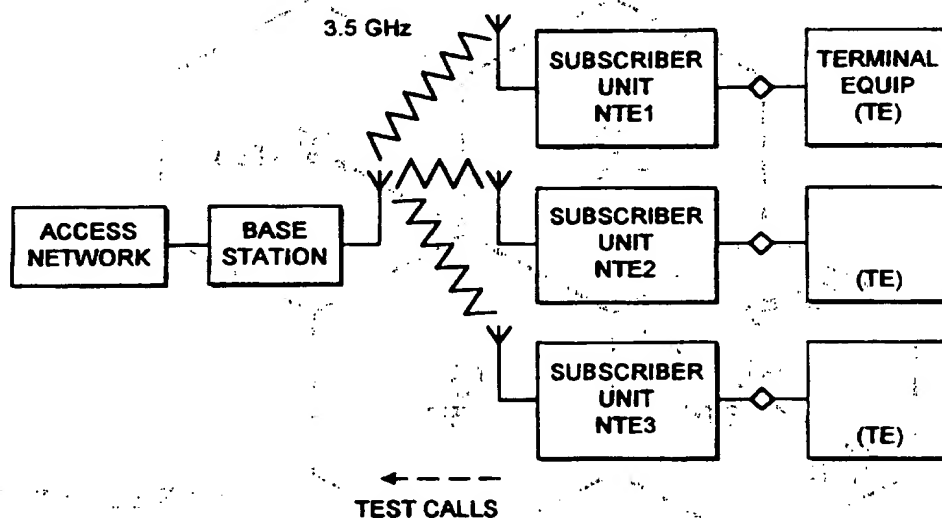
**FIG. 7**



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : H04B 7/005, H03L 5/02, H04Q 7/32		(11) International Publication Number: WO 97/17769
A3		(43) International Publication Date: 15 May 1997 (15.05.97)
(21) International Application Number: PCT/GB96/02728		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
(22) International Filing Date: 7 November 1996 (07.11.96)		
(30) Priority Data:		
9523063.7	10 November 1995 (10.11.95) GB	
9602966.5	13 February 1996 (13.02.96) GB	
9620519.0	2 October 1996 (02.10.96) GB	
(71) Applicant (for all designated States except US): IONICA INTERNATIONAL LIMITED [GB/GB]; Cowley Road, Cambridge CB4 4AS (GB).		(88) Date of publication of the international search report: 24 July 1997 (24.07.97)
(72) Inventors; and		
(75) Inventors/Applicants (for US only): MARTIN, Paul, Maxwell [GB/GB]; 9 Taylors Field, Dullingham, Newmarket, Suffolk CB8 9XS (GB); GOODINGS, Rupert, Leslie, Alexander [GB/GB]; 33 Elizabeth Way, Cambridge CB4 1DD (GB); SHORE, Christopher, John [GB/GB]; 10 Evergreens, Chesterton, Cambridge CB4 1UP (GB).		
(74) Agent: SARUP, David, Alexander; Withers & Rogers, 4 Dyer's Buildings, Holborn, London EC1N 2JT (GB).		

(54) Title: METHOD AND APPARATUS FOR POWER CONTROL IN A TELEPHONE SYSTEM



(57) Abstract

In apparatus and a method of transmitting messages in predetermined time slots within fixed length time frames, during a call a target power level of transmission is set by a second unit, the second unit is operative to measure the power level of a received message and to send a power level control signal to a first unit to adjust the power level of transmission during the call, the control signal being dependent upon the measured power level, and in which the power level of messages sent by the first unit at the start of a call is set dependent upon the power levels of messages sent by the first unit in previous successful calls to the second unit.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AM	Armenia	GB	United Kingdom	MW	Malawi
AT	Austria	GE	Georgia	MX	Mexico
AU	Australia	GN	Guinea	NE	Niger
BB	Barbados	GR	Greece	NI	Netherlands
BE	Belgium	HU	Hungary	NO	Norway
BF	Burkina Faso	IE	Ireland	NZ	New Zealand
BG	Bulgaria	IT	Italy	PL	Poland
BJ	Benin	JP	Japan	PT	Portugal
BR	Brazil	KE	Kenya	RO	Romania
BY	Belarus	KG	Kyrgyzstan	RU	Russian Federation
CA	Canada	KP	Democratic People's Republic of Korea	SD	Sudan
CF	Central African Republic	KR	Republic of Korea	SE	Sweden
CG	Congo	KZ	Kazakhstan	SG	Singapore
CH	Switzerland	LJ	Liechtenstein	SI	Slovenia
CI	Côte d'Ivoire	LK	Sri Lanka	SK	Slovakia
CM	Cameroon	LR	Liberia	SN	Senegal
CN	China	LT	Lithuania	SZ	Swaziland
CS	Czechoslovakia	LU	Luxembourg	TD	Chad
CZ	Czech Republic	LV	Latvia	TG	Togo
DE	Germany	MC	Monaco	TJ	Tajikistan
DK	Denmark	MD	Republic of Moldova	TT	Trinidad and Tobago
EE	Estonia	MG	Madagascar	UA	Ukraine
ES	Spain	ML	Mali	UG	Uganda
FI	Finland	MN	Mongolia	US	United States of America
FR	France	MR	Mauritania	UZ	Uzbekistan
GA	Gabon			VN	Viet Nam

INTERNATIONAL SEARCH REPORT

Inter. Appl. Application No

PCT/GB 96/02728

A. CLASSIFICATION OF SUBJECT MATTER
 IPC 6 H04B7/005 H03L5/02 H04Q7/32

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 H04B H03L H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	<p>EP 0 645 940 A (NIPPON TELEGRAPH & TELEPHONE) 29 March 1995</p> <p>* abstract *</p> <p>see column 1, line 11 - line 31</p> <p>see column 3, line 17 - column 5, line 17</p> <p>see column 9, line 23 - line 46</p> <p>see column 10, line 25 - line 51</p> <p>see column 12, line 33 - line 58</p> <p>see column 13, line 52 - line 57</p> <p>see claim 1</p> <p>see figures 2,3</p> <p>---</p> <p>-/--</p>	<p>20-23</p> <p>1,16,19</p>

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents:

- * "A" document defining the general state of the art which is not considered to be of particular relevance
- * "E" earlier document but published on or after the international filing date
- * "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- * "O" document referring to an oral disclosure, use, exhibition or other means
- * "P" document published prior to the international filing date but later than the priority date claimed

* "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

* "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

* "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

* "A" document member of the same patent family

Date of the actual completion of the international search

30 May 1997

Date of mailing of the international search report

13.06.97

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
 NL-2280 HV Rijswijk
 Tel: (+31-70) 340-2040, Tx. 31 651 epo nl,
 Fax: (+31-70) 340-3016

Authorized officer

Lopez Marquez, T

INTERNATIONAL SEARCH REPORT

Intern. Appl. No.
PCT/GB 96/02728

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5 056 109 A (GILHOUSEN KLEIN S ET AL) 8 October 1991	20-23
A	* abstract * see column 6, line 62 - column 7, line 6 see column 7, line 23 - line 50 see column 8, line 43 - line 52 see claim 1 see figure 6	1,16,19
A	EP 0 610 030 A (NOKIA MOBILE PHONES LTD) 10 August 1994 * abstract * see column 2, line 28 - column 3, line 3 see column 3, line 30 - column 5, line 15 see claim 2 see figure 3	1,16,19
A	EP 0 468 507 A (TOKYO SHIBAURA ELECTRIC CO) 29 January 1992 * abstract * see column 1, line 1 - line 9 see column 1, line 45 - column 2, line 8 see column 2, line 39 - line 46 see column 4, line 21 - line 28 see column 4, line 49 - column 5, line 8 see column 5, line 20 - line 35 see column 8, line 25 - column 9, line 21 see column 10, line 22 - line 34 see claims 2,9 see figures 1,6,8,10	1,16,19

INTERNATIONAL SEARCH REPORT

International application No.

PCT/GB 96/02728

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. claims 1-19: closed loop power control based on measured power level and with initial power level setting
2. claims 20-23: closed loop power control based on interference level and measured power level

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

Intern. Application No

PCT/GB 96/02728

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0645940 A	29-03-95	JP 7107033 A	21-04-95
		US 5574983 A	12-11-96
US 5056109 A	08-10-91	AU 646001 B	03-02-94
		AU 6728390 A	31-05-91
		CA 2072989 A	08-05-91
		CN 1053870 A,B	14-08-91
		CN 1090107 A	27-07-94
		EP 0500689 A	02-09-92
		IL 96218 A	27-02-94
		JP 4502841 T	21-05-92
		WO 9107037 A	16-05-91
		US 5485486 A	16-01-96
		US 5265119 A	23-11-93
		US 5257283 A	26-10-93
		US 5267262 A	30-11-93
EP 0610030 A	10-08-94	FI 930515 A	06-08-94
		JP 6303181 A	28-10-94
		US 5564074 A	08-10-96
EP 0468507 A	29-01-92	CA 2047870 A	28-01-92
		DE 69112949 D	19-10-95
		DE 69112949 T	15-05-96
		JP 5007178 A	14-01-93
		KR 9500054 B	07-01-95
		US 5303268 A	12-04-94